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# STUDIES ON HOUSEHOLD SEWAGE DISPOSAL SYSTEMS*

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Although the significance of the residential sewage disposal system in American practice has not generally been realized, I am sure that those of you who have had to deal with problems in this field are well aware of its importance in your local practices. On the national scale, it has been estimated, as of 1945; that some 17,000,000 persons were served by home sewage disposal systems, compared with 75,000,000 persons served by public sewer systems, of which some 47,000,000 were served by municipal sewage treatment. With demands for modern living conveniences in uncrowded areas, such as the fringe areas around our cities, and with increased availability of electricity and transportation in rural areas, it is quite likely that there will be continued installation of individual sewage disposal systems. For example, in recent residential building construction, 40 per cent of the homes being built with federal mortgage insurance assistance are dependent upon individual systems for sewage disposal.

Only 40 per cent of the 4,400,000 installations in use were installed under the organized control of State or local health agencies. Until comparatively recently little attention had been given to factual investigation of their behavior. This has been amply reflected in the difficulties found in this field.

The objective of the individual household sewage disposal system is the safe and convenient disposal of household waste, in a manner not

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hazardous to the health of the family, or to the community, and without nuisance. Under favorable circumstances the individual system will give adequate service. If misapplied, however, or otherwise carelessly handled, such systems are a source of embarrassment and expense to the home owner as well as a problem to the authorities.

The individual household sewage disposal system finds applicability in areas in which public sewers are not available. For rural or scattered fringe area building, consideration of the environment with respect to the individual home is usually sufficient. However, if it becomes necessary to consider use of individual systems in proposed subdivision or other development, which may amount to a "built-up" concentration of residences, careful study should be made of the environment with respect to the development as a whole, as well as to the individual homes in it. This is important because experience has shown that areas in which either ground water or impervious soil lie at relatively shallow depths, have become trouble spots after development with individual systems. Areas which overlie an underground basin are also possible trouble areas under a concentration of individual systems. In such cases the history of successful operation of systems on a few residences scattered around the vicinity may be misleading. Although the area may successfully handle small scattered loads, through lateral dispersion or the size of the basin, it may fail under the load of a development. The result is a raised local water table, surface seepage, sewage backing up into the home, etc. Development of such areas on the basis of individual sewage disposal systems should be avoided.

Before discussing the research, I would like to review briefly the household sewage disposal system, its units and some of the problems. The system starts, of course, with the house sewer. There may be one or more

sewers, depending on the house and disposal system layout. In some schemes the septic tank may receive toilet wastes or bathroom wastes only, with discharge of other wastes to separate absorption lines. Kitchen wastes are sometimes conducted to a grease trap, following which they may variously be discharged to the septic tank, by-passed around the tank to the soil absorption system, or discharged to a separate soil absorption line. The common practice, however, is the discharge of all household waste through one sewer to the septic tank and soil absorption system. Most modern recommendations do not include a grease trap for the residential system, although it is commonly recommended for restaurant, road house, institution, etc., installations where sizeable amounts of grease are discharged, and where the trap may receive the necessary maintenance.

Although the cesspool is still used in some localities, it has become pretty well recognized as a source of difficulty in anything but the most porous soils. It is not recommended nor approved in many States and local areas. The usual cesspool is a well, the lower section of which is lined with open joint stone or brick, whereas the upper section is of tight joint construction, drawn in to support a manhole or slab top. Raw household waste enters near the top and the liquid is supposed to pass through the open joints into the soil.

Most residential systems consist of a septic tank followed by a soil absorption system. The septic tank serves as a settling, digestion and storage tank, essentially prepares the sewage for further treatment and absorption in the soil, or for treatment on subsurface filters. The combination of the three functions in one device, the septic tank, is perhaps not the best technical arrangement, but it has many merits from the practical standpoint of simplicity in construction, ease of maintenance and low cost.

Structurally, it consists of a watertight chamber equipped with sewage inlet and outlet appurtenances arranged to retain floating matter and minimize short-circuiting of sewage through the tank. Provision is made for passage of gases from the tank and soil absorption system to the house stack. Means of access to the tank interior for inspection, gaging and removal of sludge and scum is usually provided. You are aware of course that the septic tank is not complete treatment, and that the effluent is still a health and nuisance hazard.

The system for absorption of septic tank effluent into the soil may take various forms. Most commonly, where tests show that shallow soil at a particular site promises adequate absorption, a system of open joint or perforated conduits laid in gravel in shallow trenches serves to distribute the effluent to the soil. Where two or more trenches are used, a distribution box serves to divide the tank effluent into portions discharged to each trench. If tests show the upper soils to be unsuitable for the shallow trench type of system, but also by test, that there is opportunity for absorption in underlying layers, a seepage pit may then be used as the means for distribution of effluent to the soil. A seepage pit is a porous-sided well, similar in construction to a cesspool, the difference being that the seepage pit receives septic tank effluent while the cesspool receives raw sewage. Since seepage pits penetrate the deeper soils they can constitute a greater hazard to pollution of ground waters than the shallow type system. In all cases the local environmental factors should be taken into consideration, regardless of the type of system being considered.

Where neither upper nor lower soil strata offer absorption possibilities, the customary alternative, if compatible with environmental factors, is discharge through a subsurface sand filter bed or sand filter trench to a

surface watercourse. Such filters have open joint or perforated pipes laid in gravel above and below the sand filter to distribute the effluent and to collect the filtrate for discharge to the surface watercourse. The public health aspects of such discharge must be considered of course and special authorization from the health department for each such system is usually required.

Concerning problems and difficulties in practice, the most frequent complaint over the country is seepage of sewage to the ground surface. This could result from steep slopes in tile lines and from the character of the soil itself, or rather failure to design on the basis of a proper investigation of the soil. In some cases, however, the root of the trouble is not the soil absorption system, but failures elsewhere, which result in clogging the absorption system. Failures, say, at the septic tank, either through faulty design or construction, or simple neglect of servicing, may go unnoticed until consequent damage to the soil absorption system reaches the point where sewage seeps to the surface, or backs up in the house. In any case the result is a clogged absorption system for which the only correction now known is relocation in fresh ground. This is expensive at best. It is obvious that on the usual residential lots the opportunities for repeated relocation in fresh ground are limited.

A poor layout invites trouble. An instance coming to mind is one in which the septic tank was placed in a low spot with absorption lines sloping downward but into higher ground. This served to drain the high ground in wet weather, flooding the tank and creating a surface pool at the tank. Some instances of tank flooding due to discharge to roof drainage to the vicinity of the absorption field are known. In these cases the scum overtopped the tank outlet fixture and passed into the absorption system; operation

was sluggish thereafter, even in dry weather.

Concerning unit design problems, one of the obstacles to good septic tank performance has been the tendency to skimp on capacity. This is false economy and an invitation to trouble, as will be explained later. Scum retention tees or baffles are important appurtenances. Sometimes they have been poorly designed, or poorly installed so that they drop off. Surprising as it may seem, tanks are sometimes designed or installed without means of access. Design of soil absorption systems on the basis of percolation tests, to determine quantitatively the water absorption capacity of the soil, is not as widely applied as it should be. Except in very porous sandy soils or in very tight clays, a decision on whether the location is suitable for the absorption type system, and as to how much absorption area is needed, based on anything short of percolation tests, leads to failure. Even the trained soil scientist must use percolation tests to determine soil water absorption capacity with reasonable accuracy, except for the extremes above mentioned. Steep slopes, as mentioned before, lead to surface seepage at the extremities.

The effectiveness of good design may be lost through careless installation. A few difficulties might be cited. Exposure of open trenches in freezing weather during construction has resulted in system freeze-ups during initial operation. Carelessly laid tile lines result in poor distribution. Inlets have clogged because the sewer had been pushed into the tank against the baffle, or because the sewer had been cut off carelessly, leaving a ragged edge to snag material. Baffles have been broken by ramming the sewer into the tank. There are instances where tanks have been installed backwards.

One of the major sources of trouble is neglect of maintenance. Some cleaners claim that in over 50 per cent of their cleaning jobs, they are called in after sludge accumulations have exceeded tank storage capacity, and spillovers

have clogged the absorption system. This is not necessarily any deliberate neglect by the home owner. It has been our experience during field inspections that the householder is usually uninformed as to the location of his facilities, what they are, and what he should do to maintain them. We found no lack of householder interest, however, and in our opinion, many difficulties will disappear when the householder is given the necessary information. There is a leaflet, "Septic Tank Care," prepared by the Division of Sanitation of the Public Health Service, available from that office, or in quantity, from the Superintendent of Documents, Washington, D. C., which should be helpful. The leaflet describes briefly the system and functions, provides guidance on maintenance, and space for a layout sketch of the system and record of servicing. The amount of attention required in these systems is very little actually, but too often the householder is left unaware of any responsibilities until sewage backs up and an expensive relocation ensues.

The studies being made by the Public Health Service Environmental Research Center at Cincinnati were started in 1947 under joint sponsorship of the Housing and Home Finance Agency and the Public Health Service. The principal objective of the studies has been to learn the facts concerning behavior of home septic tanks and soil absorption facilities, under various loading and environmental circumstances, and to make available the factual information on which improved design and installation standards might be based.

The wastes from individual homes vary considerably in quantity and composition, depending on family size, living habits and other factors peculiar to the particular home. For example, the water consumption in a group of homes which we studied averaged 39 gallons per person per day in winter and 49 in summer. In the same group the variation was from 8 to 150 gallons per

person per day in winter and 8 to 226 in summer. The character of residential waste is influenced by individual practices in the use of soaps, detergents, garbage grinders, washing machines, and sometimes, water softening units. Changes in occupancy introduce variation. As a consequence, the number of resident persons is losing favor as a yardstick of design load and in its place the number of bedrooms is considered to be a better indication of the load potentiality of a home, particularly since it includes house capacity for temporary additional loads, such as week-end or overnight guests. It is of interest that small homes, that is, two-bedroom homes, tend to have larger person-per-bedroom occupancy than three-bedroom homes, and the three larger than the four-bedroom home. Similarly, the larger water consumption per-person develops in the small home, and decreases toward the larger homes. It follows from this that unit loadings for the small home would be larger than those of the larger home. It is necessary to take such variability into account because although averages may be useful in reflecting trends, the final application must result in designs which will serve most, if not all, of the individual cases.

Concerning the septic tank, it has become evident to us that ample capacity is an important consideration. From study of sludge and scum accumulations in some two hundred home septic tanks over the country we found that the larger tank accumulates more sludge and scum per-person than the small tank. The average rate of accumulation in the group of tanks studied was found in tanks of about 125 gallons liquid capacity per-person connected, which would be equivalent to a 500-gallon size tank for a four-person family. Tanks larger than this unit size accumulated more solids; tanks smaller than this unit size, less. The effect of tank capacity on suspended solids removal was also evident in the experimental studies of full size septic tanks at the

laboratory. A group of 500-gallon single compartment tanks removed roughly 60 per cent of the suspended solids, whereas a 2,000 gallon single compartment septic tank removed roughly 80 per cent, during a year of operation over a range of sludge accumulations. Tanks having capacities of 289, 246 and 123 gallons respectively quickly reached sludge storage capacity, with accompanying drop in suspended solids removals. All of these tanks received equal sewage loadings, 250 gallons per day.

The provision of liberal capacity is not only important from the technical standpoint but it pays off economically in the long run. The cost of cleaning home septic tanks ranges from $15.00 to $300.00 in this country. A short time ago the cost of a 500-gallon concrete tank in a southern locality was $55.00 and that of a 750-gallon tank $65.00. This represents 50 per cent additional capacity for $10.00, or 20 per cent additional cost, for the tank itself. Including excavation the 50 per cent additional capacity could probably be purchased for 25 to 30 per cent additional cost, installed. The point is, that the 50 per cent additional capacity would stretch the period between cleanings to roughly two times the original period. In view of the cleaning costs above mentioned, an economic advantage is apparent.

In investigating the effect of tank shape on suspended solids removal, we found that five full-size single compartment septic tanks, all of approximately 500 gallons capacity, but of different shapes, including horizontal and vertical cylinders, rectangular, rounded end and oval types, all gave average removals between 59 and 65 per cent for a year of experimental operation. Variation in shape, therefore, had little, if any, effect on suspended solids removal efficiency.

During the early studies, two multi-chamber tanks of 550 and 670 gallons total capacity respectively, the first made up of two 36-inch vertical cylinders

in series and the second, four 24-inch vertical cylinders in series, gave suspended solids removals of 78 and 84 per cent respectively. Compared with the roughly 60 per cent removal 500-gallon single compartment tanks above mentioned, this indicated advantage to multi-compartmentation. More recently, experimental investigations of the effect of number and proportions of compartments have been undertaken. The total capacity of each tank arrangement was 500 gallons. In the rectangular shape, a two-equal-compartment arrangement showed advantage over a single compartment tank. A three-equal-compartment rectangular arrangement, however, did not show advantage over the single-compartment tank. Placing two-thirds of total capacity in the first compartment resulted in performance about the same as that of the two-equal-compartment control tank. With reversal of the arrangement, that is, one-third of total capacity in the first compartment, performance fell off below that of the control.

There is, therefore, advantage in performance to be gained, either by large increase in capacity or by multi-compartmentation. At this point in the multi-compartmentation studies it appears that a two-compartment arrangement, either with equal compartments, or with about two-thirds of total capacity in the first compartment, shows promise.

It should not be inferred from this that the well-designed single compartment tank of ample capacity will not give good performance. In well drained soils an absorption system following such a tank should have a reasonably long life. However, for the less open soils the advantage of the greater suspended solids removal and the better stability of the larger single tank, or of the multi-compartment tank, should be considered.

Among tank details investigated experimentally, tests of inlet arrangements, using uranin dye as a tracer and tank detention time and flow pattern

as the yardsticks, indicated that an unbaffled plain sewer inlet, a baffled sewer inlet and a tee fitting inlet were all essentially equal in effect on detention time, but the tee provided a slightly better flow pattern than the other arrangements. In these experiments the four-inch sewer entered each tank with invert elevation three inches above the tank liquid level. In one experiment on outlets a tee was compared experimentally with a tank-width baffled weir. There was no difference in effect on suspended solids removal among them. Concerning inter-compartment connectors, experiments using the dye-detention-flow pattern yardsticks indicated that 4-inch tee and bend connectors resulted in longer detention time and better flow pattern than a four-inch high tank-width slot submerged 12 inches to top of slot. Replacement of the slot by a single four-inch diameter hole, also at 12 inches submergence, increased the detention time and improved the flow pattern but was not quite as good as the pipe fitting arrangement in this respect. For practical purposes either the pipe fitting or hole arrangement should perform creditably.

There have been questions on the effect of tank liquid depth on performance, arising where prefabricated tanks of less than the commonly recommended four foot minimum have been offered, or where difficult installation circumstances may make a shallow tank installation more desirable. As the studies on tank shapes were made at roughly four feet water depth, another experiment was conducted to investigate the depth effect. Four single compartment tanks, all of 500 gallons capacity but varying from 28½ inches to 64 inches in liquid depth, were used for the purpose. Early trends at low sludge levels indicated no difference in suspended solids removals among the four. With start of intermittent sludge additions, performance of all four fell off. For some reason the 48-inch depth tank never recovered, although

we have had good performance from similar tanks at this depth. The remaining three recovered, with performance somewhat in favor of the deepest tank, until a second period of generally lower and erratic performance developed. During that time and during recovery the 28½-inch tank showed better performance than the 64-inch tank. Consequently, it appears possible to reduce liquid depth where necessary, without harm to performance, and possibly with slight benefit. Considering economic use of tank construction materials, shapes approaching the cube or cylinder represent a practical minimum in tank shell material. For a 500-gallon tank such design would result in a liquid depth of about four feet. Further concerning design elements. it appeared from some of the data collected in the field that sludge might accumulate to a limiting level below the bottom of a tee outlet, regardless of total liquid depth, a level beyond which solids would discharge, and that the limiting distance below the bottom of the tee outlet was about 12 inches. Recent analysis of sludge accumulation behavior in ten 500-gallon straight vertical wall septic tanks operated at the laboratory, ranging in liquid depth from 28½ to 64 inches, indicates that the limiting distances are not constant but vary with surface area, or with depth, in the equal capacity group of tanks operated at a sewage flow rate of 250 gallons per day. The limiting distances from bottom of tee to top of sludge would amount to approximately 10, 16 and 18 inches respectively for total liquid depths of 3, 4 and 5 feet, or, expressed in terms of surface area: $D = 2.6 - 0.08A$, where D is the limiting distance in feet, 2.6 a constant and A, the surface area in square feet.

Useful information on sludge and scum accumulations has been developed from analysis of data from tanks in normal operation in the field. Scum floats with about 27 per cent of its total thickness above the water line.

Rates of sludge and scum accumulations which may be expected not to be exceeded more than 5 per cent of the time may be represented by the equations:

$$\text{Scum } Y = 5.05 + 0.56X$$

$$\text{Sludge } Y = 12.45 + X$$

where: Y = cubic feet per bedroom

X = years of operation

These rates are roughly two to three times the average rates of accumulation. It is evident from this that the setting of cleaning times on the basis of average accumulation rates would invite difficulties in installations where rates are more than average. On the other hand, the use of accumulation rates which blanket most cases would force cleaning more frequently than necessary for the average case. In view of this, and mindful of the cost of servicing, the economic answer appears to be the periodic inspection or gaging of tanks, either by the householder, or by an organized service, say at one year intervals, to determine whether tank cleaning is due. A home-made device consisting of a long stick to which a strip of bath towelling is attached, lowered through the outlet fixture and left in contact a few minutes will indicate top of sludge level closely enough for practical purposes. A hinged flap on the end of a stick which may be pushed through the scum and raised in open position to gage the bottom of scum, may serve as a simple homemade scum gaging device.

Coming to the soil studies, it is of interest to consider the tremendous amounts of liquid being applied to an absorption system as compared to what soils normally absorb from rainfall or from irrigation. Average rainfall in this country ranges from 30 to 50 inches a year, with extremes up to 150 inches. Allowing for evaporation and runoff, the soil absorbs some 20 to 40 inches, with a maximum of possibly 100 inches. In irrigation,

the maximum amount of water applied annually is about 100 inches. Current home absorption field design practices, however, permit some 200 to 1,100 inches annually, with extreme cases found in the field amounting to over 2,000 inches annually. It is evident then that the quantity of liquid imposed on the soil is in itself a major factor, to which is added the complicating influence of sewage constituents.

The design of a soil absorption system involves factors such as the clogging characteristics of the septic tank effluent, the volume of waste to be disposed of, the climate of the area, and most important, the absorption characteristics of the particular soil being considered. A basic soil problem is the estimation of the absorption characteristics of a particular soil by test, a topic studied for years in agriculture and still not satisfactorily solved. There are methods and aids for estimating soil water absorption characteristics which are of some help. Soil information for many areas is published by the U. S. Department of Agriculture, in the form of soil maps and soil descriptions, which are of help. Another aid is the close visual inspection of the soil on site, the main clues being soil texture, structure and color.

Soil texture, which means the proportion of sand, silt and clay, is a common clue to permeability, as particle size governs pore size, which in turn influences the rate of water movement. Texture, as a yardstick, has limitations, and is reliable only in sandy soils. In heavier soils containing appreciable amounts of silt or clay the soil structure becomes an important additional clue.

Soil structure results from the tendency for individual textural particles, particularly clay particles, to clump together to form secondary particles of larger size. These tend to govern size and distribution of pore

space, and in turn, the absorption properties, rather than the individual textural particles. With well-developed structure a lump of soil will break apart, with little force, along well-defined cleavage planes into uniform sized and shaped units. With no structure, more force is required, and the lump will break along irregular surfaces.

Color is one of the most important visual clues to soil permeability. Bright, uniform, reddish-brown to yellow colors throughout a soil profile indicate favorable oxidation conditions, and ultimate movement of air and water, promoted by desirable moisture absorption properties. Soils which are light gray in the topsoil and dull, drab and mottled in the subsoil, indicate lack of oxidation, very restricted movement of air and water and are likely to be less permeable.

Although the clues above mentioned are of value, they do not obviate the necessity of a quantitative test of water absorption rates. The percolation test proposed by Ryon, together with his development of an empirical relationship between the clear water rate and the rate at which septic tank effluent might be applied successfully, is the basis of most of the design recommendations used by various control agencies today. The Ryon test involves the digging of a one-foot square hole to anticipated trench bottom. After wetting the soil the hole is filled to a depth of six inches with water and observation made of the time required for the water level to drop one inch. With this information, tables developed from Ryon's empirical relationship are used to arrive at the necessary trench bottom area, per unit of house loading, such as per bedroom.

We have examined the percolation test experimentally, as a consequence of which we suggest modifications which we believe to be improvements. Briefly, these are: (1) the substitution of a 4-inch bored hole for the

laborious 12-inch square dug hole; (2) the more complete saturation of the soil; (3) the use of the minimum observed rate instead of the average or some initial rate; and (4) the use of several test holes instead of one at a site. Comparative tests of 4-inch and 8-inch auger holes, and a one-foot square dug hole, in soils representing a wide range in percolation rates, have indicated that there is no significant difference in the rates among the three sizes of hole tested. A saving in labor, and in the amount of water used, develops with the bored hole. The saving in labor per hole can be invested profitably in replicating tests in an area. Due to soil variability, a single test is often useless in estimating absorption characteristics of areas as small as 100 foot square. Six tests, sometimes more, are needed in such an area to obtain a reliable estimate. The saving in water per hole becomes of significance in tests over undeveloped tracts of land, where water for testing purposes must be carried in. In securing more complete saturation before testing, opportunity is given for swelling of the soil. This is particularly important in clay soils. The use of the minimum rate, rather than the average or some initial rate is undoubtedly more representative of soil percolation behavior under conditions of actual use.

The use of existing design tables in conjunction with the slower percolation rates obtained by the modified tests in clayey soils will result in larger absorption areas than those based on the older test procedures. This is probably on the safe side. However, it is possible that under current habits of home living, sewage characteristics may be somewhat different than those upon which Ryon's work was based. There is, consequently, need for redevelopment of empirical relationships between successfully operating systems in a variety of soils, and the more refined test results. This entails field study which we hope to undertake this year through the cooperation of

a number of local public health engineers and sanitarians over the country.

Experimental studies of some of the physical, biological and chemical factors contributing to soil absorption behavior under effluent loadings are being made. Physical clogging is simply the plugging of soil pores by solids. Biological clogging, common in agricultural water spreading work results therefrom plugging of pores by biological bodies and by-products, or from destruction of soil structure by biologic activity. In the application of septic tank effluent to soil it appears from our preliminary studies that biologic activity does not cause clogging, but instead, tends to reduce the clogging tendency of other factors. Chemical clogging is also a common agricultural soil problem in the West, particularly where irrigation is practiced. "Black alkali" soils developing in some areas result from irrigation with waters high in sodium. It is considered that waters in which 50 per cent or more of the cations (sodium, potassium, calcium and magnesium), is sodium, are harmful to water absorption characteristics of a soil.

In our experimental study of the effluent sodium clogging influence, the relative amount of sodium to calcium was modified by adding gypsum to the effluent. It was found from core dosing studies that soils having a well-developed structure tended to maintain the structure and clog less under the calcium fortified effluent dosage than with normal effluent dosage. In single grained soils, with no apparent structure, there was no difference in the rate of clogging between the fortified and normal effluent dosed cores. Some proprietary septic tank "cleaning" compounds contain caustic soda. Soil cores dosed with effluents to which caustic soda had been added, in concentrations well below those expected from a typical "cleaning" dose, caused immediate clogging and accompanying damage to soil structure. Similar, although less dramatic, results were demonstrated using potassium hydroxide.

Sodium hydroxide is indeed used as a dispersing agent in soil textural analysis to destroy structure and reduce the sample to its textural elements. When so dispersed soil becomes an impermeable mass.

Changes in living habits bring up questions of their effect on the sewage disposal system. Current questions concern the effect of ground garbage, detergents, automatic washers, brine waste from regeneration of home water softeners, and various proprietary "aids" being offered in this field.

Ground garbage represents an additional solids load, for which either the storage function of the tank must be expanded to provide for the increased rate of accumulation, or cleanings must be made at more frequent intervals. We surveyed a number of systems in the field not long ago, including installations receiving ground garbage waste, and found that there is at least 50 per cent average increase in sludge plus scum accumulations, as compared with tanks not receiving ground garbage in the group. In this case it appeared that the greater part of the increase was in the scum. On the basis of what information there is, the 50 per cent increase in total tank capacity recommended by the Joint Committee on Rural Sanitation for installations receiving ground garbage appears to be a reasonable precaution. As I mentioned previously, an increase in capacity, whether the tank ever receives garbage or not, is not a loss, but an economic saving in the long run. There is evidence from the laboratory studies that septic tanks receiving ground garbage will require larger absorption fields. Soil cores, ranging from silty clay to rather heavy clay, were dosed with effluents from tanks receiving ground garbage and sewage, and sewage only, as a control. Cores receiving the garbage-sewage effluent clogged more rapidly than those receiving the sewage effluent, both on a time, and solids-for-solids basis. The additional soil

area required for the garbage-sewage effluent treated cores, to equalize the clogging rates, would be roughly 25 to 35 per cent. The recent examination of systems in the field indicates that there is more organic matter in soil samples from systems receiving ground garbage than from those not receiving garbage. Further information will become available on this when the analysis is complete. On the basis of what is now known, I feel that an increase of 50 per cent in design absorption field size would be a reasonable precaution against failure due to inclusion of ground garbage.

The effect of detergent use in the home, on the individual sewage disposal system, is being studied. Bottle anaerobic digestion experiments on a fresh sewage plus ripe sludge mixture, to which varying amounts of one commercial anionic detergent were added, indicated only slight interference, by this particular detergent, at the levels of interest in home sewage disposal. Although the detergent used is of a class representing the bulk of production, differences in specific active agents, as well as differences in "builders" which make up the whole product, vary among brands. The behavior of a number of popular household detergents is being studied. A quantity of the detergent above mentioned equivalent to that used in a four load wash is being added once a week to a full size experimental septic tank in operation at the laboratory. Thus far there has been no adverse effect on either grease or suspended solids removal as compared with the performance of a control tank. Concerning the effect of another anionic detergent on soil absorption systems, studies in which detergent and soap respectively were added to tank effluents, indicated no differences in clogging tendencies other than those associated with differences in the amount of suspended solids. Similar studies using tap water suspensions of grease and soap, and grease and detergent did show differential clogging.

There was immediate tendency for the soap-grease suspensions to cause greater clogging than the detergent-grease suspensions. Increasing quantities of grease in the soap suspensions caused slight increases in clogging, but the quantities of grease in the detergent suspension showed no apparent correlation with clogging. Recent experiments in which wash waters from a home washer, using soap one week and detergent the next, were applied to laboratory soil cores, indicated no differences in clogging rates on either a time, or solids-for-solids basis. However, there was evidence of some increased damage to soil structure under detergent dosage, which may cause increased clogging from a long time viewpoint.

In a few cases coming to our attention, the use of automatic sequence washing machines tends to change the laundering pattern from the usual Monday to laundering through the week. This may mean sub-capacity loads with full use of water, for some machines at least, with possible additional waste volume to the sewage disposal system. More work is needed on this.

In a recent study of the effects of salt brine, we simulated weekly discharges of brine, as from periodic regeneration of a home water softener, to a full-size home septic tank. Although salt stratification developed and some bottom layers reached concentrations inhibiting to a normal sludge, no interference with digestion in the septic tank was noted. The principal reasons were the failure of high concentration layers to accumulate in quantities sufficient to envelope the accumulated sludge, which was about 1.2 feet deep, and the tendency for the sludge to become acclimated to the saline environment. Increased digestion activity with rising spring temperatures resulted in mixing of tank contents, and consequent destruction of the high concentration layers. This behavior might not necessarily develop in a tank having little sludge accumulation when brine discharges start, such as in a new tank, or a tank

returned to service without seeding sludge. Dosage of soil cores with effluent from a tank receiving sewage and brine waste from simulated softener regeneration indicated no short time damage to percolation rates as compared with normal effluent, but there was some damage to soil structure, which may be important from a long time viewpoint. Field examinations are to be undertaken on this later.

Questions on additives purported to "condition," "start" or even "clean" tanks come up frequently. Experiments at Cincinnati, using brewers' yeast, and those previously reported by Heukelekian using bakers' yeast, indicate that yeast has no merit as a "starter." Some of the so-called cleaners on the market contain caustic soda. In an experiment in which caustic soda was added to a full-size home septic tank which had been in normal experimental operation, the pH rose to 12.4 and remained above 11.0 for about five days; digestion virtually ceased, and the sludge swelled in volume. Had the tank reached solids storage capacity, sludge would probably have been discharged, with consequent damage to soil absorption. A reasonably well-designed and operated septic tank needs no such props. If inadvertent discharge of interfering materials has upset tank action, or if the tank has reached sludge storage capacity, the simplest and safest servicing procedure, considering the protection of the soil absorption system, is to pump out the tank. As I mentioned before, caustic soda will cause clogging in clayey type soils. Currently there appears to be considerable promotion of additives purported to contain enzymes and bacterial cultures, for which various claims are made. Although there may be possibilities for "starters" here, the necessity for any additives after digestion is established is not evident, since anaerobic digestion

carries on naturally and adequately in the septic tank. It is, in fact, designed to take advantage of the naturally occurring action. As you know, ripe sludge is an adequate starter; well rotted barnyard manure has also been used for this purpose. In starting tanks in cold climates, and probably in starting tanks which are to receive ground garbage, a starter would be of advantage. However, concerning the proprietary additives, it appears to me that it is up to the promoters to prove any claims made. Comparison of anaerobic digestion of sewage under the influence of such "aids" as against normal anaerobic digestion of sewage plus ripe sludge mixtures, in controlled bottle experiments, would be the first approach. The testing of proprietary products is not within the scope of our project.

In closing, I should like to emphasize a few thoughts which should be kept in mind in dealing with household "septic tank systems." The first is that the septic tank is not a disposal system of itself, but is an important unit of a process in which the objective is the disposal of a large amount of waste liquid, mostly into the soil. Soil, for waste disposal purposes, is a sensitive medium, not only sensitive to the heavy liquid loadings usually placed on it, but susceptible also to damage from abnormal changes in the waste being applied to it. We should keep this in mind, not only in considering septic tank design and operating factors, but also in connection with servicing procedures. The second thought is that while the development of factual information is of fundamental importance, it will fall short of its purpose if it is not applied effectively in the field; that is, incorporated into the design, installation, operation and servicing of each individual installation.